TORPEDO SWIMRUN CAPE TOWN: UNDERSTANDING ATHLETES, EVALUATION OF RACE RULES AND ASSESSING PREDICTORS OF PERFORMANCE OF A NOVEL SPORT

by

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DECLARATION

I, *Christina Helena Geromont*, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Abstract

Aims: The first aim was to describe the characteristics and demands of the Torpedo SwimRun Cape 2019 race. The second aim was to determine predictors of race performance, by using entry, result and questionnaire data.

Objectives: The first objective was to explore distributions of age (y), sex, 1km pool swimming time (mm:ss), 5km road running time (mm:ss), competency level (Likert scale), estimated race finishing time (hh:mm), training habits (min/week and sessions/week), background sport (type), equipment used (type), wave selection (athletes select if they want to start in a slow, medium or fast wave)(type), total and segment race times (mm:ss) and questionnaire scores of race participants. The second objective was to analyze segment and race result times, 5km run times, 1km swim times and ocean knowledge questionnaire results.

Results: In total, there were 99 participants (288 athletes took part in the race) of which 36% were female and 64% were male. Each team in the Torpedo SwimRun Cape must consist of two athletes. Of the athletes, 53% were entered in male teams, 30% in mixed teams (a male and a female per team) and 17% entered in female teams. The median age was 41 years with an interquartile range (IQR) of 19 years. The mean race time was 174:15 mm:ss (± 29:51 mm:ss). Athletes trained on average 7 sessions/week (IQR 7 sessions/week), and 435 min/week (IQR 345 min/week). The median ocean knowledge score (OKQ) was 9 (IQR 4). Athletes' self-reported current 5km road running time was on average 25:00 mm:ss (IQR 07:41 mm:ss) and their current 1km pool swimming time was 18:00 mm:ss (IQR 07:02 mm:ss). Total race time was significantly associated with current 5km road running time ($\rho = 0.488$, $p = 0.001$), current 1km pool swimming time ($\rho = 0.607$, $p = 0.001$) and OKQ score ($\rho = -0.349$, $p = 0.003$). These three variables were also used to predict total race time. The over-all linear regression model was found to be significant ($R^2 = 0.514$, $p = 0.001$).

Conclusion: The athletes that participated in the Torpedo SwimRun Cape 2019 display a large variance in their training habits, particularly their training loads. It was found that the performance in this SwimRun race was not only dependent on how trained athletes were, but

also their ocean knowledge. Ocean knowledge is a learned skill and not necessarily attained by swimming in the ocean more (training open-water swimming was not associated with OKQ score). The OKQ questionnaire showed that better scores were associated with faster total racing time. The model used to predict performance accounted for approximately half of the variation seen in total race time. There is a clear need to further understand how performance is affected in SwimRun races. Repeat studies should be done to investigate different training strategies (also taking an athlete's team partner into account), the effect of various environmental exposures and how different equipment influence racing.

Chapter 1 – Introduction

Fifteen years ago a group in Sweden trialled a concept of swimming and running multiple times in an alternating fashion. The rules included that the course had to be traversed with all of their equipment at all times, regardless of the diversity of the terrain, and that each team of two had to stay with each other at all times. Thereafter, the group asked other people to join them. After a successful trial, this grew into a successful sport and is now known as SwimRun (Otillo SwimRun, 2019). Following the staging of the race, several other countries introduced their own versions of SwimRun (Karlsson, 2019), followed by the creation of the World SwimRun Federation (World SwimRun Federation, 2019). The South African SwimRun instalment, namely the Torpedo SwimRun Cape, was introduced in South Africa in 2017 (Torpedo SwimRun, 2017).

Unlike other endurance sports such as biathlon, SwimRun is unique as it requires competitors to race with a partner, wear all racing equipment throughout the race and athletes are required to complete multiple alternating running and swimming segments. For example, in a biathlon race, there are only two segments (one running and one swimming segment) whereas in SwimRun there are more segments (always more than one running and one swimming segment). The terrain also varies in SwimRun races. The race organisers decide what type of terrain athletes must face. Runs could be on beaches, unmarked trails, marked trails, roads and rocks. Similarly, swims can take place in the ocean, lakes, dams, etc. Racing with a partner adds a unique aspect to this race. Poorly matched partners can have a negative impact on race performance. In contrast, well matched partners can plan race strategies together and both perform optimally. The effect of how unfamiliar environmental terrain and racing with a partner influence race performance is unknown.

The Torpedo SwimRun Cape uses the same rules as the Ötillö SwimRun, where competitors must race with a partner. Therefore, the race consists of teams of either males, females or mixed (males and females). Compulsory equipment includes a wetsuit, swimming cap, Torpedo SwimRun bib, shoes, and a whistle. Goggles, pool buoys, hand paddles, and a pull rope are optional. The total distance of the Cape race is 16km, consisting of six swim segments (totalling 4km) and six run segments (totalling 12km). The race starts in Sandy Bay, Cape Town, and finishes at Clifton fourth beach, Cape Town. Teams must race along the Atlantic coastline alternating between running and swimming (Torpedo SwimRun, 2019).

As the race has evolved the number of participants and level of competitiveness has increased. There are questions about the safety and performance of competitors. However, there is scarce research available to provide evidence-based answers. Therefore, this thesis will explore these gaps in knowledge with the following scope: a literature review to evaluate current knowledge on SwimRun (Chapter 2) followed by an experiment designed to investigate questions pertaining to the SwimRun athletes and demands of the race (Chapter 3), which include analysing the different race segments, the athlete segment times, environmental exposures and factors that influenced race performance.

Chapter 2 - Literature Review of SwimRun

Introduction

SwimRun is a sport that originated in Sweden about fifteen years ago. It is a unique sport that now takes place internationally, including South Africa. There are currently over 500 races available (Karlsson, 2019). The sport has shown increases in number of races, number of participants and competitiveness. It has been reported that the growth of SwimRun currently is larger than that of triathlon in the early 2000's (Culp, 2020). The races attract high profile competitors who compete for prize money. In general, not much is known about the physiological demands of this sport and the physical demands on the competitors.

Therefore, the scope of this review is to explore the race format, analyze the existing literature on SwimRun, identify unique challenges in this race and discuss future ideas for research.

SwimRun Race Format

SwimRun is a race in which competitors usually race with a partner. The categories are either male, female or mixed. All racing is done together, therefore it is not a relay, and depending on the race, partners may not be separated by more than a certain distance at any point during the race (this distance may vary depending on the race). A few races do not require competitors to have a partner. These races either take place in still-water (for example lakes) and/or are of short distance. Competitors have compulsory equipment, which is defined depending on the race but usually consists of a wetsuit (if a cold-water swim), swimming cap, an event vest and running shoes. Goggles, hand-paddles, flotation buoys and tether ropes are optional.

The race consists of multiple segments of running and swimming, hence the name of the sport "SwimRun". Throughout the race, participants alternate between swimming and running multiple times. The distance of each these segments varies depending on the race. Events can be considered as ultra-endurance races, such as the Ötillö World Champs (10km swimming, 65km running), or they could be short for example, the Cape Val de Vie race (2km swimming and 8km running). The swimming segments mostly take place in the ocean and the running segments vary between road, trail, unmarked trail, etc. Due to this, there is always large variability in the terrain, weather and ocean conditions the competitors will be exposed to.

Several traits make SwimRun unique compared to other endurance sports such as biathlon and triathlon that combine swimming and running. Firstly, SwimRun differs from both in that athletes are required to race in all their equipment at all times. I.e. run in their wetsuits and swim caps and swim with their running shoes on. Biathletes and triathletes are not required to do this and as such make use of transition stations to change race clothing. Secondly, SwimRun athletes are also allowed to swim with hand-paddles, buoys and use tether ropes (tied between the partner so that the stronger athlete can pull their partner during a segment if needed). Both of those additions are banned in biathlon and triathlon. Thirdly, in biathlon and triathlon, there is only one swimming and one running segment, whereas in SwimRun, there have to be at least two segments of both running and swimming. Lastly, in triathlon there is the cycling leg, which is absent from SwimRun.

Existing literature on SwimRun

The following keywords were used: swimrun, swim-run, swimrunners, swimming and running (in conjunction with one another). Searches were performed on various platforms including PubMed, Scopus, Google Scholar, Science Direct, PRIMO and Ovid. Only two scientific papers on SwimRun were retrieved using these criteria.

The first paper published on SwimRun is an intervention study that assessed the effect of mental imagery and motivational self-task training on the rating of perceived exertion (RPE) and flow state during a SwimRun race (Ferrari, Chirico, and Rasa, 2016). Flow state, as described by the authors of this paper, is a “positive experiential state, which occurs when the performer is totally connected to the performance, in a situation where personal skills equal required challenges". The authors used SwimRun as a sport modality because they wanted to test their intervention on people participating in a "really tough" endurance race. In their study, they used 22 males who had raced in at least one SwimRun race before. Eleven males were randomly assigned to either a control group (received no mental training) or to an intervention group (received mental training). They hypothesized that receiving additional mental training would result in a better over-all race experience (lower RPE and better flow state). Both groups had two physical training sessions a week for eight weeks before the SwimRun race. The physical training sessions were tailored to each participant’s percentage of maximum heart rate. The intervention group also did several 60-minute-long sessions of mental imagery and motivational self-task training for a month leading up to the SwimRun race. After the SwimRun race, the authors measured RPE and flow state. Flow state can be measured by using a validated questionnaire, called a Flow State Scale. The authors found that the intervention group reported a significantly lower RPE and a significantly improved flow state after they completed the race. They concluded that mental training is a useful tool in improving race experience, however, they admitted they did not control for a placebo effect (control group received no placebo training instead of the mental training). In addition to this, the authors did not report the average race times of the two groups, therefore it is unknown whether the mental training benefitted the performance of the intervention group or not. They also did not show whether the two groups were performance-matched at the start and end of testing. It would also have been beneficial if the terrain of the SwimRun race was described because it would be useful if this mental training helps for "flat" racing or more environmentally challenging racing.

The second paper was an observational study which aimed to assess the race times and participation in SwimRun over four years (Lepers, Li, and Stapley, 2018). In this study, the race time and participation data of the Ötillö world series were used (five races used in this study) from 2012-2016. A linear regression analysis showed that on average the male teams decreased their overall race times by 17 min/year, the mixed teams 40 min/year and the female teams 59 min/year. The performance gains are large, and the authors concluded that this was mainly due to increased race experience gained. However, they only used the top three winning teams of each year. Due to the sport being relatively new, there is a good chance that in each year there are more new professional participants, hence the large gains in performance. Also, only using three top teams is a small sample size and high variability could be introduced. It would perhaps be more accurate to use the top ten teams per category of each year for example. When pooling all participation data, they found that the male teams made up 66% of races, mixed teams 23% of races and female teams 11% of races. It is interesting that the female participation is so low. In contrast, a race in Cape Town (Val de Vie) reported a 54% female participation (Geromont, 2019). It should, however, be noted that the race distance is shorter compared to the races analyzed by Lepers et al. (2018). It could be that shorter races are more appealing to female participants, therefore the level of race experience being a strong determining factor for race participation.

In addition to participation, the study of Lepers et al. (2018) also revealed the percentage of people that did not finish (DNF) races. Of all races, DNF varied from as low as 4% and up to 33% of race participants. The race in which the highest DNF took place (33%) was a race in Germany where it was reported that the water temperature was about 10 ^{0}C and the air temperature was 5-10 ^{0}C. These cold conditions could be dangerous for race participants. The safety guidelines for minimum water and air temperatures in SwimRun have not been set. This is also important because the SwimRun sport being new, many athletes that compete do not come from an open-water swimming background (Geromont, 2019). That is made evident in the race with the lowest DNF rate (4%) which was the Ötillö world championship. Participants had to qualify for this race and were thus all experienced. In conclusion, the authors explained that the performance gains that were seen will likely eventually plateau as more race experience is gained and there is an increased (and more constant) participation in races. They point out that a limiting factor is that they were not able to measure an athlete’s “experience” or “knowledge” in the extreme race environments and that this likely has a noticeable effect on race performance. Therefore, it would be important to know how much this influences race performance, as this is something that any SwimRun athlete could improve. To do this, a tool needs to be developed and validated to measure a person's experience or knowledge, particularly in the ocean as this is where athletes are exposed to ocean currents and waves.

“Extreme” thermoregulation: Safety First

As with most sports, the priority is for the safety of the competitors. In SwimRun races, there are first aid stations, medical staff and water safety personnel. However, no research has been conducted on the risks associated with the race. Therefore it is difficult to know which symptoms are hazardous to athlete safety in this sport. As with other endurance sports, participants could experience exercise-associated symptoms of exhaustion, cramping, hyponatraemia, dehydration and hyper- or hypothermia (Schwellnus, 2009; Speedy et al. 2001; González-Alonso et al. 1997; Kay and Marino, 2010; Giesbrecht, 2000). However, SwimRun has unique demands that are not present in other sports, in particular the effect of alternating between running and swimming multiple times. This can be challenging when swimming in cold ($\pm$ 12 °C) Atlantic water and running in warmer air temperatures ($\pm$ 25 °C) wearing a wetsuit.

The physiological responses to both heat and cold exposures have been studied (Castellani and Tipton, 2016; Wendt, Loon, and Lichtenbelt, 2007). When exercising in the heat, the body responds by vasodilating vessels near the skin, increasing sweat loss, usually an increased cardiac output and behavioural changes (Wendt et al. 2007). In contrast to this, being exposed to the cold results in decreased blood flow to the skin via vasoconstriction, an increased metabolic rate to produce more heat and eventually shivering (Castellani and Tipton, 2016). The body usually adapts to different temperatures in healthy athletes, however, the response can be altered if an athlete has performed prior exercise (Castellani and Tipton, 2016). Castellani et al. (1999) found that prior exercise resulted in a blunted response to adapt in cold temperatures, known as “thermoregulatory fatigue”. In their study, ten males underwent two treatments on different occasions before being exposed to cold air for two hours. The first treatment was to cycle for 60 minutes at 55% VO_2max before cold air exposure, and the second treatment was to be passively heated (resting in 38 ^{0}C water) before being exposed to cold air. The authors found that exercising before cold exposure resulted in a significantly lower mean rectal temperature during cold air exposure (from the 40th minute until the end of the two hours) and greater heat loss compared to passive heating (not exercising before cold exposure) (Castellani et al. 1999). This is important when considering SwimRun because before each swimming bout (cold exposure), athletes have done running (and as the race goes on, each swim is preceded by an increasing number of swims and runs) which could lead to a blunted response to cold exposure. There are two implications of this: firstly this raises concern for participant safety, and secondly, this alters performance as colder core temperatures result in poorer performance (Tipton et al. 1999).

Interestingly, swimming-related problems are not always as a result of hypothermia. It has been suggested that sudden deaths during open-water swimming could in part be due to an abnormal cardiac event known as "autonomic conflict" (Tipton, 2013). After the first exposure to cold water, the autonomic nervous system is influenced in two ways (Castellani and Young, 2016). Firstly, cutaneous cold receptors respond to the cold temperature by inducing a cold shock response, via the stimulation of the sympathetic nervous system. The cold shock response is characterized by hyperventilation (leading to hypocapnia), increased heart rate and inspiratory gasps (Barwood et al. 2013). Secondly, at the same time, facial cooling and wetting lead to a diving response via the parasympathetic nervous system. This is associated with bradycardia, apnoea and vasoconstriction in the limbs and trunk (Gooden, 1994). The two responses have conflicting effects on the heart, hence the term "autonomic conflict". This has been linked with cardiac dys- and arrhythmias, which are risk factors of sudden cardiac arrest (Tipton, Kelleher, & Golden, 1994). Athletes with cardiac pathologies would be at higher risk of this occurring. Especially in a sport such as SwimRun, where cold water immersion occurs several times (not just once like in other sports that involve cold water swimming), it would thus be important to improve health screening in the entry forms before the race and provide more information to race participants. Health screening could be done by asking athletes, as part of online race entry, to check off a list if they suffer from any conditions known to be health risk factors when doing a race. Information regarding the risks of completing such a race could be published online and be e-mailed to all entrants.

Is fitness everything?

SwimRun is influenced by an athlete's terrain experience and could improve race performance, due to the highly variable outdoor environment in which SwimRun races occur (Lepers et al. 2018). Unfortunately, the authors were limited in this regard because currently, no tool exists to measure an athlete's knowledge/experience about the SwimRun race environment. Specifically, in the ocean, the only type of formal testing that occurs is for people that are employed to work on or under the water. Due to the currents and waves that SwimRunnners are required to face in races, the closest sport where ocean ability is formally tested is surf lifesaving.

Tipton et al. (2008) studied the effect of prior exposure to the ocean on swimming performance (Tipton et al. 2008). The sample group included 35 surf lifeguards (with ocean experience) and 30 pool lifeguards (no ocean experience). The best effort of the lifeguards in the 200m swim in the pool, calm sea, sea with surf (waves present), underwater swim test, and 30s swim bench test were measured. The mean swimming times in the pool and calm sea were similar, however, the surf lifeguards had a significantly faster mean 200m surf swim time than the pool lifeguards. All other measurements, including anthropometrical characteristics, were similar. When all the measured factors were considered, the strongest performance predictor of a surf swim was ocean experience (R^2 = 0.32; p<0.01). The authors concluded that experience in the ocean had a detectable difference in surf swimming. However, the authors did not define what they meant by experience, which could be linked to anything including thermal habituation, control over anxiety, a learning effect of swimming through currents waves or a combination of these (Tipton et al. 2008).

Physiological adaptations can be achieved in response to being exposed to hot and cold environments. Heat acclimation improves exercise performance in the heat (Lorenzo et al. 2010; Schmit et al. 2017) and repeated cold water immersions improve exercise performance in the cold. The latter is as a result of improved thermogenesis and decreased cold sensation, but interestingly the adaptation is greater when repeated cold water immersions are done statically (resting) rather than exercising in the cold (Golden and Tipton, 1988). Repeated cold water immersions can save as much as 20% total heat production, compared to when no habituation has occurred. This would most likely affect endurance performance (Janský et al. 1996).

Habituation in the cold can also affect the cold shock response, which is related to athlete safety. Barwood et al. (2013) (check study) studied the effect of various cold-water immersions on the cold shock response and how anxiety relates to this. The reason for this is because of the safety hazard implications of the cold shock response when doing cold water swimming: increased respiratory rate (hypocapnia), increased heart rate, confusion, disorientation and a large inspiratory gasp that could result in breathing in water (Castellani and Tipton, 2016). In this study, two tests were performed. In the first test, 11 participants were subjected to two water immersions in random order. The one immersion (labelled control, "CON") was at 15 ^{0}C for seven minutes and the other immersion (labelled anxiety, "ANX") was also at 15 ^{0}C for seven minutes, but the participants were deceived beforehand that the water was 5 ^{0}C colder even though the temperature had not changed. In the second test (ten people remained) the participants underwent seven repeated cold-water immersions, but in immersions six and seven, anxiety was stimulated the same way as in study 1. In both studies, anthropometry, anxiety (on a 20 cm scale), cardiac frequency, respiratory frequency, tidal volume and minute-ventilation were measured. It was found that in study 1 (ANX versus CON group responses), just being told that the water was colder than it actually was resulted in the ANX group having significantly higher levels of anxiety, higher cardiac frequency and minute-ventilation. In study 2 (repeated immersions), it was shown that repeated immersions lead to a decreased ventilatory response compared to their original cold shock response, but the increased cardiac frequency had not changed. This study showed two things. Firstly, there is a strong mental component when being exposed to cold water that is unrelated to the actual temperature of the water. If that can be trained, then that would already make swimming safer (decreased volume of air breathed in results in a lower chance of aspirating saltwater). This is particularly important in the context of SwimRun, where athletes are subjected to several cold-water immersions, thus experiencing several cold shock responses. Being prepared in advance would likely lead to safer race conditions. Secondly, the study showed that repeated immersions decrease the effect of the cold shock response. The mechanism of whether it is due to mental training, or physical adaptation is unknown because it was not measured. However, both results relate to ways of gaining experience, which could affect both race safety and performance, which are worth considering for SwimRun.

There are many aspects that relate to the experience or knowledge of the race that can influence an athlete's safety and performance. It would be useful to construct tools to measure these different aspects separately. It is in the interest of both beginners and elite competitors to know more about these factors. Firstly the information will make racing safer, and secondly, the information may convert into performance gains. These performance gains are distinguishable from the performance gains associated with fitness or endurance training.

Implications of the unique demands of SwimRun

As mentioned previously, SwimRun is a unique sport as it differs from other endurance sports in several ways: having to race with a partner, the kit that is worn, environmental exposures and the format of the race.

Due to the nature of these challenges, all these factors could affect performance. For example, racing with a partner means they have to go at the pace of the slowest partner in the team. This is important as it alters one's pacing strategy. The reason for racing with a partner is primarily for safety reasons, but it also adds an interesting aspect to this race. The positive aspects of racing with a partner include that the partner could provide motivation to train and race and assist in uncomfortable situations. Also, a partner can provide slip-streaming benefits in certain segments of the race. However, it is necessary to have careful planning between partners before races to ensure the strengths and weaknesses of the partners are synchronised. Planning must be careful because if one's partner is feeling weak or having a bad day, that influences the racing of the entire team. How much planning and preparation before a race is unknown. Various aspects still need to be explored, including the amount of training to be done together, racing strategies and how help should be exchanged between partners.

Not only does one have to race with a partner, but all the racing must be done in the same kit throughout the race. Although there is racing kit designed specifically for SwimRun (Karlsson, 2018), compromises have had to be made for the kit to be able to be worn when running and swimming. For example, wetsuits have to be thick enough to keep racers warm during swims, however, if they are too thick they could restrict movement in running and also be heavier than normal running clothing. Shoes have to be worn to run in, however, this makes feet heavier when swimming, possibly posing biomechanical impedances on efficiency. Due to the environment being so variable, it would be useful to study how different apparel can affect racing.

The environment also poses unique difficulties. Most SwimRun races will not be cancelled if weather is adverse (for example large waves, cold temperatures and strong winds). This was shown in a SwimRun race in Germany where the DNF (did not finish) rate was 33% (Lepers et al. 2018). Therefore, it is necessary to train in the same or similar environment to prepare for any condition. However, there are unanswered questions about training. For example, the type of training in these specific environments and the proportion of training in the exposed environments, such as the ocean, of overall training remains unknown.

All these examples highlight a need for further research to assess how different training programme styles can affect racing. As Lepers et al. (2018) explained, there are large performance gains in the sport at present, but those gains will eventually plateau. To further improve racing times it is pertinent to eventually investigate SwimRun specific training strategies rather than using strategies from biathlon or triathlon. This would increase participation in the novel sport and increase the proportion of elite athletes.

Future direction and conclusions

It is evident that SwimRun is a unique sport with its own demands and differs greatly from other endurance sports. Therefore, there is justification for research into this new sport. There are many unknowns regarding racing safety, the effect of SwimRun exposures on athletes and predictors of performance. SwimRun currently is undergoing exponential growth and thus the need for research is becoming more relevant. This is necessary for racing to become safer from an organizational perspective and for athletes to adopt training strategies to allow both safer and faster racing. Open-water swimming consists of approximately half of the total time of a SwimRun race but is generally under-researched due to the difficulty in creating research tools and protocols that can withstand the variable environment. Therefore, there is a need to create tools and protocols to study this field before SwimRun specific questions can be researched. Generally, the initial step in conducting research would be to characterize the various races and athletes. This would help with other research questions, including to determine what the predictors of performance are in SwimRun races, and how much each predictor influences it. Specifically, with regards to athlete safety, it would also be useful to know what the effects of repeated cold shock exposures are in SwimRun athletes and the effects of other environmental exposures as these have not yet been determined. Monitoring this could be done by using ingestible telemetric pills which will measure athlete core temperatures to ascertain whether there are noticeable changes in core temperature and how it relates to performance and athlete safety (with regards to hypothermia). More research topics will emerge after initial studies are conducted. This would allow the growth of the sport, which would lead to more financial support from sponsorships to sustain races and research.

The next chapter (Chapter 3) is written as a stand-alone study. Firstly the specific research questions of this study will be identified. This will be followed by a description of the methodology used to collect the data to answer the questions, followed by a discussion of the results. The final chapter (Chapter 4) will discuss the implications of the findings and suggestions for future research.

Chapter 3 – Experimental Design:

TORPEDO SWIMRUN CAPE TOWN: UNDERSTANDING ATHLETES, EVALUATION OF RACE RULES AND ASSESSING PREDICTORS OF PERFORMANCE OF A NOVEL SPORT

Introduction

SwimRun is a sport where athletes must alternate between several running and swimming segments within one race. The sport has grown internationally, including in South Africa, where four SwimRun races are hosted: Torpedo SwimRun Cape, Val de Vie, Wild and Cradle Moon. Each race has a different format. This study will focus on the Cape race, which most closely resembles international SwimRun races.

The Torpedo SwimRun Cape race uses the same rules as the Ötillö SwimRun, where competitors must race with a partner. The race consists of teams of either two males, two females or one male and one female (mixed team). Compulsory equipment includes a wetsuit, swimming cap, Torpedo SwimRun bib, running shoes, and a whistle. Goggles, pool buoys, hand paddles, and a pull rope are optional. The Cape race is 16km in total, consisting of six swim segments (totalling 4km) and six run segments (totalling 12km). Teams must race along the Atlantic coastline, starting in Sandy Bay and finishing at Clifton fourth beach, alternating between running and swimming (Torpedo SwimRun, 2019).

There is a need to characterize the SwimRun race according to the equipment being used, the level of competency among athletes, training habits and the changing environment that athletes are exposed to. Anecdotal observations show that performance in either running or swimming are not the only predictors of performance in the SwimRun race (Lepers et al. 2018). Terrain experience and knowledge of environmental conditions also seem to influence race performance. This needs to be explored further. However, a tool to assess participants' ocean knowledge or experience does not exist.

The Torpedo SwimRun group in South Africa also needs additional research to be conducted to make safer race rules. For example, the organization does not know how well trained an athlete has to be to complete the race within the cut-off time and to finish it safely. They are also unaware of the ocean competency needed to complete the swims in the Cape Atlantic seaboard.

Therefore, the first aim of this study is to describe the characteristics and demands of the Torpedo SwimRun Cape 2019 race. Distributions of age (y), sex, 1km pool swimming time (mm:ss), 5km road running time (mm:ss), competency level (Likert scale), training habits (min/week, type of exercise sessions/week), background sport (type), equipment used (type), total and segment race times (mm:ss) and questionnaire scores of race participants will be explored.

The second aim is to determine predictors of race performance. This will be achieved by using data derived from the entry forms, race result times, 5km run times, 1km swim times and ocean knowledge.

Methodology

Ethical Considerations

This study received ethical clearance from the Human Research Ethics Committee, Faculty of Health Sciences, University of Cape Town (HREC 289/209; HREC 663/2019; HREC R011/2019).

Study Sample and Recruitment

In total, 140 participants were recruited. Of these, 41 were excluded due to either not reporting to race registration, or withdrawing from the race. The data of the remaining participants (n = 99) were included and analyzed. All participants (n = 36 females and n = 63 males) were 18 years or older. Forty-four participants were in a team with someone that also participated in this study. Thus, there were 22 full teams in this study (i.e. both people in 22 teams participated in this study). The participants were entered in 17 female teams, 52 male teams and 30 mixed teams.

Data Collection

Entry and race result data of all participants were obtained after informed consent was received by a recruitment email that Torpedo SwimRun, the race organizer, sent to all Cape race entrants (**Appendix 1**). The entry and race result data included total and segment race time, personal information (date of birth, contact details, medical information, team-mate information), team entered (male, female or mixed), team start-wave selection (slow, medium or fast). Participants wore timing bands which triggered the recording of their segment times and overall race time. These data were obtained after the race from the freely accessible website of the race organisers (Torpedo SwimRun, 2019).

Within the recruitment email (**Appendix 1**), SwimRunners were given the option to provide consent to be contacted in future by the research team conducting this investigation. If consent was provided, those SwimRunners were then contacted by the research team via email (**Appendix 2**). The second email included a link to the informed consent of this study (**Appendix 3**) and a questionnaire (**Appendix 4**). Seventy-three of the 99 participants completed the questionnaire. The questionnaire was designed to get information about participants' contact and personal details (name, contact details, age, height, weight, sex and race category entered for), training habits, race preparation, race experience, and ocean knowledge (**Appendix 4**). The ocean knowledge questionnaire consisted of ten multiple choice questions with a maximum score of 12 points. A higher score indicated better ocean knowledge.

Weather conditions for the race were retrieved via archived weather forecasts for Camps Bay (an area that was included in the race) on an online weather service (Windguru, 2019). Water temperature was measured with a hand-held thermometer at Sandy Bay where the race started.

Statistical procedures

Study sample characterization

Normality of data was assessed by using the Shapiro-Wilk test. Normal data are presented as mean (± standard deviation). Non-parametric data are presented as median (interquartile range). Age (y), weight (kg), height (m), background sport (type), sex, current 5km running time (t), current 1km swim time (t), equipment used, competency (Likert scale), ocean knowledge (U), training habits results and race results are all explored. Correlations were performed using Spearman's rho. Significance was accepted at $p \leq 0.05$.

Performance prediction

Three variables were used to predict performance: current 5km road running time, current 1km pool swimming time and ocean knowledge questionnaire scores. Multivariate analysis and linear regression were used to determine the influence of these factors on race performance. Significance was accepted at $p \leq 0.05$.

Results

Weather Conditions

Weather conditions on race-day are shown in **Table 1** and **Figure 1**. Both wind and swell directions were southerly, which likely contributed toward a faster race (athletes raced in a south to north direction). At the start of the race, the primary swell had a 2.3m swell-height component, but the waves on all beaches were smaller. Here, "swell" refers to a wave of moving water that is unbroken, typically found further out at sea. A "wave" refers to a wave of water that is about to break or is broken. Waves are usually found closer to shore. The beaches in this study are West-facing, thus providing shelter from the primary swell. Wave period was also short (under 10s), therefore resulting in lower-energy waves. The ocean temperature was 9.8 ^{0}C.

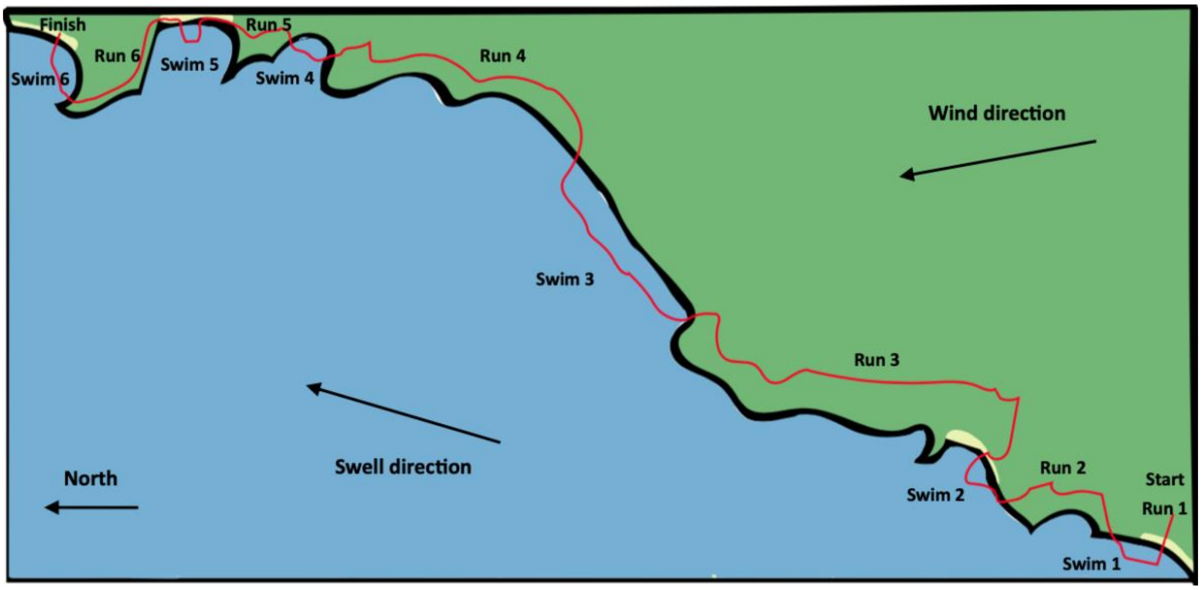

Figure 1: Map of Torpedo SwimRun race. The map indicates the start and finish of the race. The route is shown by a red line. All swims and runs are shown on the map. Location of geographical North is shown on the bottom left-hand corner. Swell and wind directions are as indicated.

Table 1: Weather conditions on race-day. Weather information is given between 5:00 and 14:00. The race started from 06:30 and officially ended at 14:00.

Time	Wind speed (km/h)	Wind direction	Swell size (m)	Swell direction	Wave period (s)	Air temperature (^{0}C)
05:00	26	SSE	2.4	SSW	8	15
08:00	26	SSE	2.3	SSW	8	16
11:00	20	SSE	2.2	SW	9	17
14:00	31	S	2.4	SW	9	17

Race Segments

Table 2 shows every race segment, their distances and the average race time. The segments from the start of the race until the end of the Llandudno run were not individually measured due to equipment limitations. Those segments are run 1, swim 1 and run 2, which can be seen on **Figure 1.**

Table 2: Race segment overview. Table shows six run and six swim segments. Each segment has information on its name, the running terrain (all swims were in the ocean), the distance of each segment, and the mean time and standard deviation of all individuals (race time was normally distributed, table 3). The first segment time encompasses runs 1 and 2 and swim 1.

Segment	Name	Type	Distance (m)	Mean time (mm:ss)	Std deviation (mm:ss)
Run 1	Sandy Bay Run	Trail, Sand	1200		
Swim 1	Sandy Bay Swim		500	29:30	05:24
Run 2	Llandudno Run	Rock, Trail	1300		
Swim 2	Llandudno Swim		900	13:48	02:24
Run 3	Oudekraal Run	Sand, Trail, Road	4300	30:24	04:42
Swim 3	Oudekraal Swim		1300	30:36	06:36
Run 4	Bakoven Run	Road, Rock	3400	26:36	05:12
Swim 4	Bakoven Swim		300	09:24	03:24
Run 5	Camps Bay Run	Sand	700	04:30	00:54
Swim 5	Camps Bay Swim		400	08:36	02:00
Run 6	Clifton Run	Grass, Rocks	900	14:18	03:12
Swim 6	Clifton Swim		400	06:48	01:42

Athlete characterization

A table showing all normality tests of other variables are shown in **Appendix 7** and **Appendix 8**. Average results are shown in **Table 3**, **Figure 2** and **Figure 3**.

The athletes' ocean knowledge was also measured and included in **Table 3**. The questionnaire (**Appendices 5 and 6)** was created and validated before the SwimRun race. Details of this process are shown in **Appendix 9**.

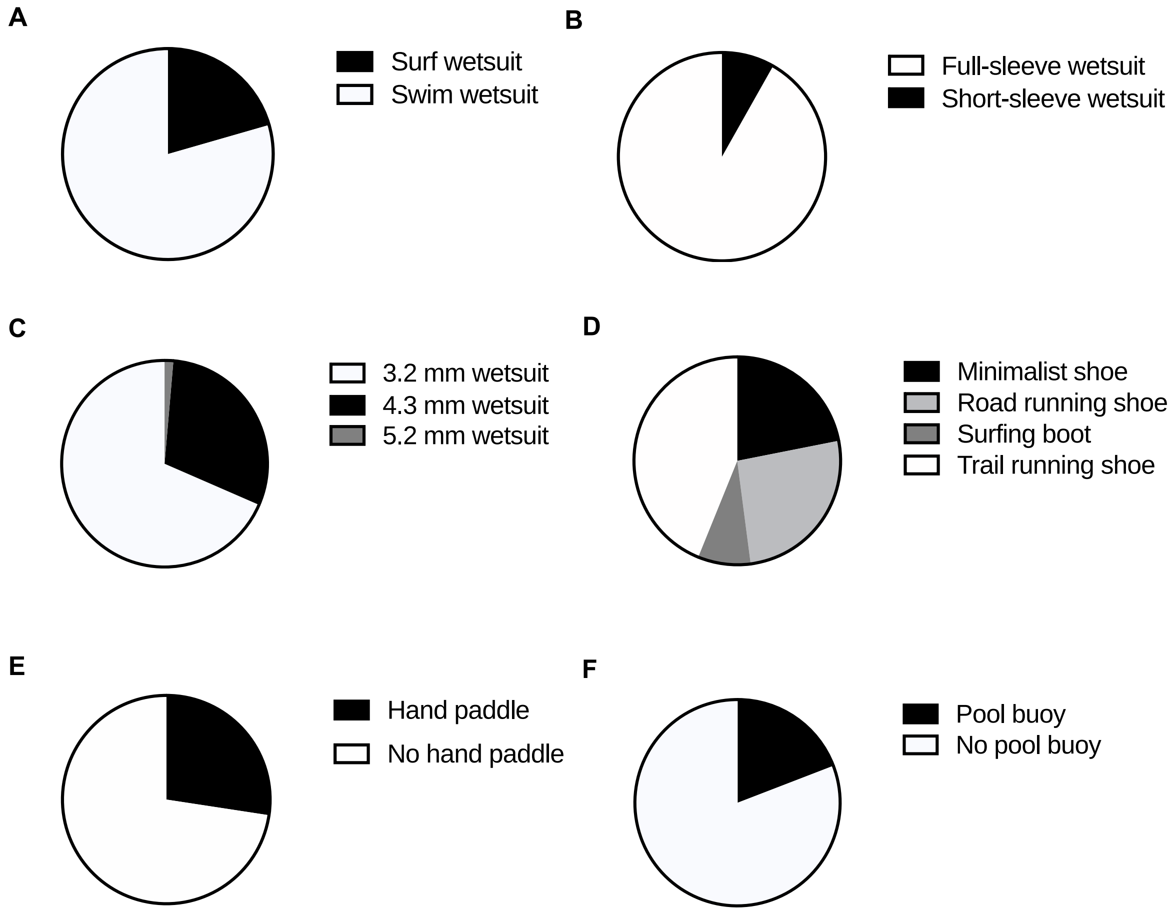

Figure 2: Equipment use by SwimRun athletes. Pie charts are used to describe the use of equipment. Panel A: Type of wetsuit worn. Panel B: Length of wetsuit worn. Panel C: Thickness of wetsuit worn. Panel D: Type of shoe worn. Panel E: Hand paddle use. Panel F: Pool buoy use.

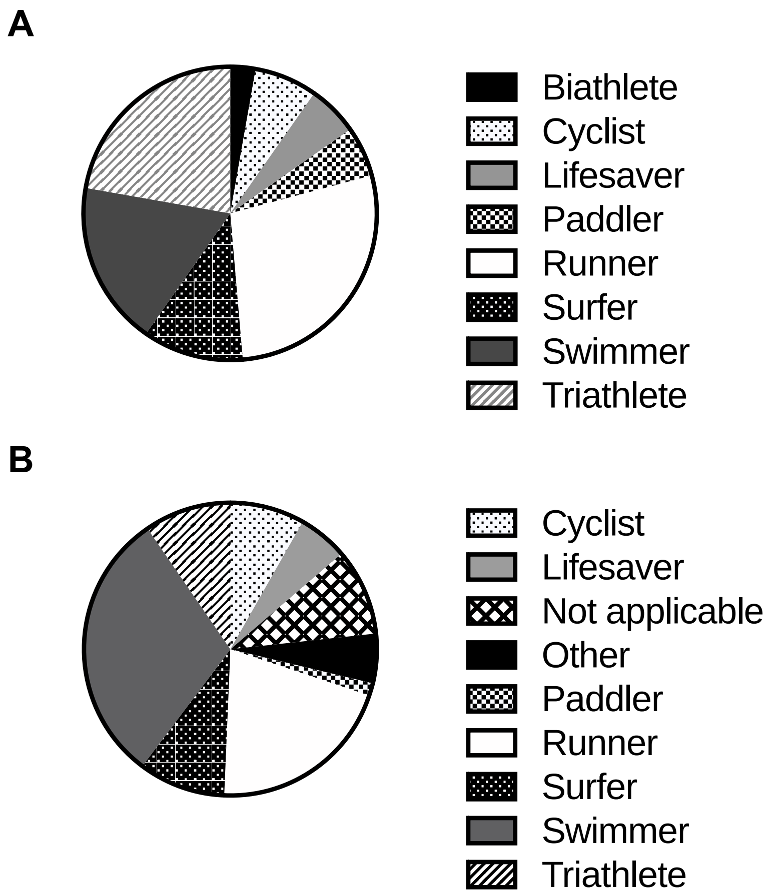

Figure 3: Primary and secondary athlete types chosen by SwimRun athletes. Each athlete was asked to list the type of athlete they primarily and secondarily classify as. They are shown respectively in panels A and B.

Table 3: Athlete overview. OKQ (Ocean Knowledge Questionnaire); SD (Standard Deviation); IQR (Inter-quartile range); S-W (Shapiro-Wilk test), 5kmRoadRun (current 5km road running time), 1kmPoolSwim (current 1km pool swimming time). Number and time of sessions refer to all training sessions per week. *significant.

	Mean	Median	SD	IQR	S-W *p* value
Age (years)	38	41	11	19	0.005*
Total race time (mm:ss)	174:15	174:05	29:51	36:10	0.131
Number of sessions (per week)	8	7	4	7	0.001*
Time of sessions (per week)	508	435	320	345	0.001*
OKQ score	8	9	3	4	0.002*
5kmRoadRun	26:02	25:00	05:32	07:41	0.009*
1kmPoolSwim	19:07	18:00	06:05	07:02	0.001*

Performance variables

The variables of interest that relate to performance were the current 5km road running time (5kmRoadRun), current 1km pool swimming time (1kmPoolSwim) and the Ocean Knowledge Questionnaire (OKQ) score. The performance metric of interest was total race time.

The 5kmRoadRun, 1kmPoolSwim and OKQ score correlate with total race time (**Table 4** and **Figure 4**). 5kmRoadRun and 1kmPoolSwim positively correlate with race time (ρ = 0.488, p = 0.001 and ρ = 0.607, p = 0.001, respectively). This means that the faster the 5kmRun and 1kmSwim times are, the faster the total race time is. OKQ score correlates negatively with total race time (ρ = -0.349, p = 0.003). This means that the lower the knowledge of the ocean (a worse score), the slower the athlete is.

Total race time also significantly correlated with three questions relating to self-perceived ability in the ocean. Those variables were comfort in waves and currents (ρ = -0.370, p = 0.001), confidence in knowledge of ocean currents (ρ = -0.543, p = 0.001) and confidence in entering and exiting all of the swims (ρ = -0.434, p = 0.001).

OKQ score was not significantly correlated with any self-reported training variables, except for number of surf sessions per week (ρ = 0.241, p = 0.041) and number of road running sessions per week (ρ = -0.285, p = 0.015). 1kmPoolSwim and 5kmRoadRun did not correlate with OKQ score.

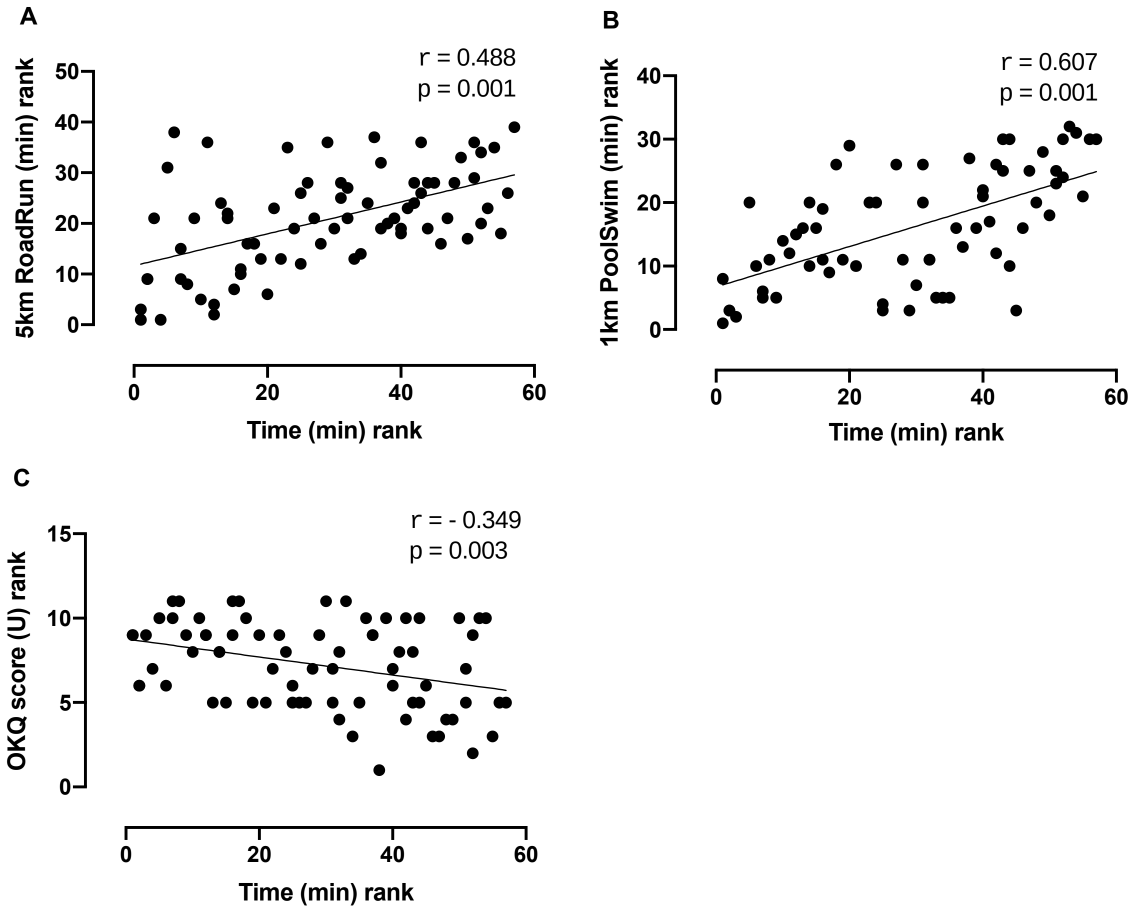

Figure 4: Associations with total race time of all athletes. Panel A: current 5km road running time correlated with total race time. Panel B: current 1km pool swimming time correlated with total race time. Panel C: Ocean Knowledge Questionnaire (OKQ) score correlated with total race time. Spearman's rho correlation was used for all correlations. Significance was accepted at a $p \leq 0.05$.

Table 4: Correlations with total time in all athletes, males, females and teams. All variables were shown to be non-parametric, therefore Spearman's rho rank test was used. "OKQ Best" denotes the best OKQ score of the team of two. "OKQ Worst" refers to the worst OKQ score of the team of two. "All" includes 73 individuals, "Males" include 46 individual males, "Females" include 27 individual females, and "Teams" include the 44 participants that comprise the 22 full teams in this study. *significance.

	Variable	Correlation with total time	*p* value
All	OKQ	-0.349	0.003*
	5kmRoadRun	0.488	0.001*
	1kmPoolSwim	0.607	0.001*
Males	OKQ	-0.329	0.031*
	5kmRoadRun	0.433	0.004*
	1kmPoolSwim	0.516	0.001*
Females	OKQ	-0.429	0.029*
	5kmRoadRun	0.463	0.017*
	1kmPoolSwim	0.780	0.001*
Teams	OKQ Best	-0.185	0.493
	OKQ Worst	-0.643	0.007*
	5kmRoadRun	0.728	0.001*
	1kmPoolSwim	0.577	0.019*

5kmRoadRun, 1kmPoolSwim and OKQ scores were used to predict total race time as shown in **Table 5**. All variables significantly predict total race time when looking at all individuals. The over-all model was therefore significant and accounted for 51% of the variance seen in the total race time. No collinearity was detected.

Table 5: Predicting total race time using OKQ, 5kmRoadRun and 1kmPoolSwim. Outcomes of the linear-regression model and individual are variables shown. Adj (Adjusted); Unst (unstandardized); St (standardized); Coeff (co-efficient). *significant.

	R^2	Adj. R^2	F change	F change *p* value
Model	0.514	0.492	22.9	0.001*
	Unst. B	St. Coeff. B	t	*p* value
Constant	106.06		5.943	0.001*
OKQ	-2.675	-0.223	-2.528	0.014*
5kmRoadRun	1.552	0.269	2.934	0.005*
1kmPoolSwim	2.597	0.497	5.355	0.001*

Discussion

The first aim of this study was to characterise athletes that took part in the Torpedo Cape 2019 SwimRun, and secondly to assess predictors of performance in this race. It was found that the athletes that participated in this study were varying in their training loads, types of sports trained, equipment used, ocean knowledge and other factors. This made the athlete field diverse. As expected, self-reported current 5km road running times and 1km pool swimming times were associated with performance. It was also found that participants' ocean knowledge questionnaire scores were associated with total race time.

In this study, all training and performance parameters were not normally distributed, showing a higher portion of better performing individuals than slow individuals. All athletes finished the race before the cut-off time, except for two teams that had to withdraw due to medical reasons. This in itself shows that SwimRun in Cape Town is attracting more individuals that are well trained and also that the race is competitive. In fact, the record for the fastest time the race has been completed in was broken by a mixed team (the winning team) and another male team. The record being broken by two teams could be attributed to the increased competitiveness, and therefore specific training focussed on SwimRun. Another factor to consider is the fast racing conditions on the day. The South wind and South primary swell would have aided the athletes race faster as the race course is from South to North.

The sample consisted of 36 females and 63 males. Within the males, just over 50% entered in Male teams. However, the opposite was seen in females where under 50% entered in Female teams. The spread of team entries is similar when compared to other international SwimRun races (Lepers et al. 2018). In both the Cape SwimRun and Ötillö series most of the team entries are comprised of male teams (53% and 66% respectively), followed by mixed team entries (30% and 23% respectively) and the least being female team entries (17% and 11% respectively).

Most of the athletes primarily classified themselves as runners, and secondarily as triathletes. Although participants classified themselves mostly as runners or triathletes, the sport that most said they participated in regularly was pool swimming. Participants trained in many sports that were not specific toward SwimRun such as surfing, cycling, paddling, etc. (**Figure 3**). This shows that the athletes that participate in this SwimRun are not necessarily training only for SwimRun, which was the case for most athletes. It could be because there are currently only four races in South Africa (all in different locations), therefore there are not enough races locally to justify SwimRun being an athlete's primary sport. However, every race to date has been sold out according to the race organisers, therefore there is likely potential for the sport to become bigger in South Africa.

With regards to the equipment used, most people stated that they ran in trail shoes, followed by road running shoes (**Figure 2**). This was a surprising finding as most of the running segments take place on the road, sand and grass for which trail running shoes do not provide a noticeable advantage. An explanation is that when traversing wet rocks and seaweed athletes feel safer wearing trail shoes rather than road shoes. The minimalist shoes (commercially available for SwimRun) are advertised to be the best shoes to use (Karlsson, 2018). They are designed for running on this type of mixed terrain, but also to provide better efficiency during swimming (the shoes are lighter, therefore less weight on feet when kicking), although this needs to be tested. The shoe-tops have large holes which allow water to flow through them, unlike traditional running shoes. These shoes do, however, require athletes to train with them, because of the low heel drop (less cushioning). How different shoes quantitatively affect swimming performance is unknown. Most athletes did not use a pool buoy for floatation or hand paddles. The pool buoy can be used to assist the legs to float, especially when wearing water-logged shoes (added weight on feet). Hand paddles make swimming faster due to the larger surface area on the hand, but that also increases the load. Swimming for an extended period with hand paddles could cause swimmers to fatigue quicker. Hand-paddles increase mean swimming velocity by requiring the swimmer to produce higher pulling and pushing forces (Gourgoulis et al. 2008). This, in turn, decreases stroke rate, which may cause some discomfort for swimmers (Gourgoulis et al. 2008). Hence, training with this equipment is necessary before a long-distance race. Another factor that could explain why athletes mostly chose not to use buoys or hand paddles is that it would make the running more cumbersome having to carry extra equipment. There are excessive varieties of different shoes, wetsuits and other equipment available on the market currently. Therefore, some companies have started to make equipment specific for SwimRun (Karlsson, 2018), but this gear needs to be further researched so that SwimRun athletes can feel more certain when purchasing new equipment.

Majority of the participants wore full length wetsuits and the most common wetsuit thickness was 3.2 mm. The Atlantic coast of Cape Town is known to be cold, which justifies why the majority wore full length suits. The race-day water temperature was 9.8 ^{0}C, which is 7 ^{0}C colder than the average ocean temperature in Cape Town in November (World Sea Temperature, 2020). It is noteworthy that the temperature is 6.2 ^{0}C colder than the coldest permitted water temperature (16 ^{0}C) for competitive open-water swimming, which is regulated by FINA (FINA, 2017). It would be useful to test in the future how different wetsuit types impact running efficiency. The thinnest wetsuit, 3.2 mm, should theoretically have the lowest impact on running but then warmth during swims is sacrificed for this. However, the most important reason to assess which wetsuits should be recommended to wear in certain ocean temperatures should be governed by safety. Cold-water racing exposes athletes to cold-shock responses (Castellani and Tipton, 2016). Globally, there is a concern in deaths (mainly due to cardiac arrests) during triathlons. In the United States of America, over 80% of recorded deaths during triathlon races occurred during the swim (Harris et al. 2017). In the Cape SwimRun race, two teams were unable to finish the race due to being too cold. Future SwimRun studies could include the use of ingestible telemetric body core temperature sensors to ascertain the effect of multiple cold water swims on core temperature when wearing different gear. This method of measuring core temperature has been validated and been used in other exercise settings, due to being a more practical method of measuring core temperature especially in race settings (Byrne and Lim, 2007).

The Ocean Knowledge Questionnaire (OKQ) was devised to test the hypothesis that an athlete's experience in the ocean influenced the performance of the Cape Town SwimRun race. After its validation (**Appendix 9**), it was used to investigate how ocean knowledge related to performance. Not unexpectedly, neither the current 5km road running or current 1km pool swimming times were correlated with OKQ score. Interestingly, neither were any of the pool and open water swimming training variables related to OKQ score. This suggests that ocean knowledge is a learned skill, and not something one gains by training swimming alone. This corresponds with a previous study that attempted to study the effect of ocean experience in the surf (beach) versus pool lifeguards (Tipton et al. 2008). The only training parameters that the OKQ score was correlated with were the number of surf sessions per week and road running sessions per week. However, the range of sessions per week was not large, therefore the correlation should be interpreted with caution. The 5kmRoadRun and 1kmPoolSwim times were correlated with each other and this is probably because the participants who are faster in either running or swimming tend to be more trained in general. The sample included people who can both run and swim, therefore that correlation was expected.

OKQ score, 5kmRoadRun and 1kmPoolSwim all correlated with total race time as hypothesized. The better an athlete's ocean knowledge, 5kmRoadRun and 1kmPoolSwim, the faster an athlete raced. This was seen when testing all individuals together, only males, only females, and teams together (**Table 4**). Within the complete 22 teams, the slowest 5kmRoadRun and 1kmPoolSwim times of the two were chosen as a team could only go as fast as the slowest team-member. However, it was not known whether the better OKQ score or the worse OKQ score would significantly correlate with total race time. It was thought that the team-member with more experience in the ocean could help the lesser experienced team-member. Essentially, the less experienced team-member would only have to follow the lead of the more experienced team-member. The better OKQ score was in fact not associated with the total race time, suggesting that help that may be received has minimal effect during the race. The worse OKQ score did correlate with performance. This means that the person that has less knowledge of the ocean is more likely to hinder the team's performance rather than being able to effectively being helped by the more experienced person. This has implications in training strategy. It would be beneficial for SwimRun teams to train this aspect of the race to avoid being slowed down by lack of experience.

These three variables were also used to see how much each one influenced total race time (**Table 5**). The overall model was significant, and the contribution of each variable to the model was also significant. The model accounts for 51% of the variance in race time. The strongest predictor was the current 1kmPoolSwim. There were similar results when testing all individuals, only men and only females. Importantly, the model showed that OKQ score had a quantifiable effect on race performance. In a previous study on SwimRun, the authors mentioned there was likely an effect of ocean knowledge/experience but they did not have a way to quantify it (Lepers et al. 2018). The rest of the over-all variance that is unaccounted for is most likely due to the effect that the other team-member has within the team. Unfortunately, this study's sample only contained 22 full teams which is too few to reliably test three predictor variables. This is important as the results reveal how significant the effect is of racing with a partner. It would be vital to consider this in the training regime of SwimRun teams. The model would most likely change depending on the ratio of running to swimming, the race terrain and the environmental exposures on the day.

Chapter 4 – Conclusions and Future Directions

The sample of participants in this study participated in a variety of sports differing in type and duration. This shows that SwimRun in South Africa can still be regarded as a social-level sport. There are a few athletes that are specifically trained in both running and swimming that are the exception to this. However, perhaps the large variance in sports trained is one of the aspects that make SwimRun unique. The race attracted not only runners and swimmers but also triathletes, lifeguards, surfers, cyclists, biathletes and paddlers. The sport is clearly accessible to those of different sporting backgrounds and that highlights the potential for growth, unlike other sports.

The large spread in training variables could also be indicative of a lack of training programs geared toward SwimRun. Future research topics should include alternative training strategies and how they influence SwimRun performance. Research should also investigate how different equipment affects racing performance. There is an abundance of available equipment and SwimRun athletes may not know what to buy and use in the race setting. This is important for performance and safety. Future studies should also investigate thermoregulation in the context of the multiple swims and hence multiple cold water shocks. An understanding of how the body adapts and responds to this unusual physiological stress will have implications for the safety and design of equipment.

This study shows there are an additional two variables that influence racing performance that are not related directly to the physical fitness of one individual. These are the effect of ocean knowledge or experience and the effect of racing with a partner. Ocean knowledge is a skill learned by repeated exposures in the ocean, but this needs to be studied further. It likely improves SwimRun performance by enabling those with better ocean knowledge to navigate through the swim segments faster. Having experience in the ocean translates to being aware of where ocean currents are, how they work, how to body-surf waves back to shore, etc. Ocean knowledge can probably be taught, however, the results showed that if partners' ocean knowledge is mismatched, the worse score correlated significantly with performance during a race setting. Racing with a partner has a great effect, approximately 50% in the Cape

Town 2019 race, due to the speed that your partner can race at (the team can only go as fast as its weakest link), as well as their ocean knowledge. By how much the two variables affect performance would change depending on the racing conditions. The study was, however, limited by the sample size. Particularly, there were not enough participants with their team-mate that took part. For this reason, the linear regression model was limited and could only account for 51% of the variance in performance. The prediction would likely have been more accurate if full teams could be assessed. Repeat studies would reveal how performance is linked to changing environments and the effect of racing with someone. Future studies could also assess different performance-measuring variables (heart rate, speed, rate of perceived exertion, etc.) during races, which could be easily done with the sophisticated wearable devices that are currently available (Seshadri et al. 2019).

Generally, this study has provided a glimpse into the type of athletes that compete in SwimRun and the factors that affect race performance. There are over 500 races in the world currently. Repeating this type of study with other races in the world would be useful to create a continuum where it is known how different athlete training factors, environmental factors, distances, etc. affect performance in any race. This is also useful information for other aspects of sport-growth, such as being able to supply data to potential sponsors, governments for permits to access land to race on and to generate more athlete interest.

In conclusion, this study showed that athletes that participated in the Torpedo SwimRun Cape 2019 race came from a large variety of sporting backgrounds. The results showed that self-reported current 5km road running and 1km pool swimming times were both associated with total race time. Ocean knowledge was also significantly associated with performance. These three variables were able to predict performance with a reasonable amount of accuracy. The results showed that performance during a SwimRun race is dependent on the training status of the athletes and also their knowledge of and experience in the ocean.

Acknowledgements

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Appendices

Appendix 1: Informed Consent (Torpedo SwimRun Cape 2019 Entry and Results information) sent via email

Dear Torpedo SwimRunner (Name),

We have exciting news!
Torpedo SwimRun is embarking on a new journey to conduct research on this new, emerging sport by the division of Exercise Science and Sports Medicine (University of Cape Town, UCT). There has been no prior research on SwimRun, making this a first in the world.

In order to proceed with this, UCT is asking you for your consent that:

1) Your entry and race result data for the 2019 Torpedo SwimRun Cape race may be registered on a UCT database and used by Torpedo SwimRun and their research partner for research purposes only
2) The purpose of registering this data is to understand the group of competitors better, to ultimately implement safer and fairer rules and to characterise Torpedo SwimRun as a new sport
3) There is an understanding that all researched or published information will be depersonalized, anonymously treated and kept confidentially
4) You may be contacted in future by Torpedo SwimRun's research partners offering to participate in future research projects that are linked to Torpedo SwimRun

Please click on the box below if you are providing consent to allow Torpedo SwimRun's research partner to register your entry and result data
☑

Please click on the box below if you are providing consent to allow Torpedo SwimRun's research partner to contact you in future regarding future SwimRun studies

☑

Research participants may stand a chance to win a free team entry to the 2020 Torpedo SwimRun Cape!

If you have any questions related to this research, please feel free to contact the Torpedo SwimRun team or Christina Geromont from UCT: grmchr005@myuct.ac.za (073 922 0040)

Should you have any ethical concerns, please contact the University of Cape Town Human Research Ethics Committee: marc.blockman@uct.ac.za

Appendix 2: Email sent from research team to SwimRunners that provided consent to be contacted further

Dear Torpedo SwimRunner,

Thank you for giving your consent for our research team to contact you!

The Division of Exercise Science and Sports Medicine (University of Cape Town) is conducting a research study together with Torpedo SwimRun. This study is designed to characterize the race participants and understanding factors that influence race performance. The goal of the study is to make the race safe and fair for all competitors.

If you are interested in participating in this research, please click on the following link that includes:

- Informed Consent
- A questionnaire

Please note that if you wish to complete the questionnaire, you will need approximately 15-20 minutes to do so.

If you have any questions please feel free to contact me!

Kind Regards,

Christina Geromont

Grmchr005@myuct.ac.za

Appendix 3: Informed consent for Total SwimRun Questionnaire

Dear Sir or Madam,

Thank you for considering participating in this study, which is being conducted by a research team from the Division of Exercise Science and Sports Medicine (Department of Human Biology, University of Cape Town). The following section describes why this study is being conducted, what it involves for a participant, the risks of participation, ethical considerations, the contact information of the researchers and the details around providing consent to participate.

Scope and purpose of the research

SwimRun is a relatively new sport, which was founded in Sweden about 15 years ago. The sport has spread throughout the world, including South Africa.

The demands of the sport have not been characterized. Also, not much is known about the competitors and the factors associated with success in the sport, or the minimum criteria that should be imposed for entry.

In addition to characterizing this new sport, it is essential for the race organizer (Torpedo SwimRun) to be able to make the race safer with fairer race rules.

What are the aims of this study?

There are several aims to this study:

1. To characterize the race terrain and participants in Torpedo SwimRun Cape 2019
2. Determining the minimum fitness and competency required to complete the Torpedo SwimRun Cape 2019 safely and within the time limit
3. Evaluate the waiting time in the sin-bin to ensure fairness to all competitors

4. To predict race performance using several variables, particularly the contribution of one's ocean knowledge and experience

Who is eligible to participate?

Anyone that has entered for the Torpedo SwimRun Cape 2019 race is eligible to participate, except for minors (under 18 years old).

What will the study involve?

If you agree to participate, an informed consent form will be provided to you to sign. At any point will you be able to ask any of the researchers questions that are related to this study.

After signing consent, you will be provided with one online questionnaire. This questionnaire consists of several sections, which include questions around your training habits, race preparation, race experience, and ocean knowledge.

Thereafter, you will participate in the Torpedo SwimRun Cape 2019 race with no intervention from the researchers. One investigator will be located at the sin-bin to record competitors who opt for the sin-bin instead of the Llandudno swim.

Your entry and race data (for which you have already provided consent to be registered on a UCT database) together with your questionnaire results will then be used to answer our research questions.

Are there any risks in participating in this study?

There are no risks associated with completing the online questionnaire. All data will be kept confidentially on secure computers and will not be shared with any party outside of the research team without the consent of the participant. Prior to presenting data and results, all information will be depersonalized in such a way that no information will be linked to you.

Are there any benefits in participating in this study?

There is no direct benefit in taking part in this study. You will be able to receive feedback after the race occurs. Those that take part in this study, may stand a random chance to win an entry to the Torpedo SwimRun Cape 2020 race.

Ethical considerations

This study has been approved by the University of Cape Town Human Research Committee. This means, that this study will be conducted according to the principles of the Declaration of Helsinki (2013, Fortaleza, Brazil) and the laws of South Africa. Participants will only be able to participate in this study once they have signed a consent form and are aware of their voluntary participation. Participants may withdraw from this study at any stage without having to provide a reason. The investigator will also be able to withdraw a participant from the study at any time. It will be the investigator's responsibility to keep all information confidential. This will be done by keeping all data on encrypted computers on a secure facility. Only the research team of this study will have access to (unless the participant provides consent to sharing information). Should the data be published or presented, all information will be depersonalized.

What if something goes wrong?

The University of Cape Town will not be responsible for any injury, loss and/or harm that may be sustained where the loss is caused by:

- Not following protocol instructions that are provided by the investigator
- Injury, harm and/or loss that is caused by lack or insufficient action to deal adequately with a side effect
- Negligence on your part

If I have any questions or concerns, who can I speak to?

If you have any ethical concerns or queries, please contact the Human Research Ethics Committee.

University of Cape Town Research Ethics Committee
Room E24-25, Faculty of Health Sciences, Old Main Building of Groote Schuur Hospital
Anzio Road, Observatory
7925
Email: marc.blockman@uct.ac.za

Any queries related to the study itself, please contact any of the investigators.

Christina Geromont
Sports Science Institute of South Africa
Boundary Road, Newlands
7725
Cellphone: 073 922 0040
Email: grmchr005@myuct.ac.za

Associate Professor Andrew Bosch
Sports Science Institute of South Africa
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Telephone: (021) 650-4578
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Professor Mike Lambert
Sports Science Institute of South Africa
Boundary Road, Newlands
7725
Telephone: 021 6504558

Email: mike.lambert@uct.ac.za

CONSENT

I, the undersigned, have been informed about the University of Cape Town's study, "TORPEDO SWIMRUN CAPE TOWN: UNDERSTANDING ATHLETES, EVALUATION OF RACE RULES AND ASSESSING PREDICTORS OF PERFORMANCE OF A NOVEL SPORT", which is to be conducted by the Division of Exercise Science and Sports Medicine within the Department of Human Biology, Faculty of Health Sciences.

I agree to:

- Complete a questionnaire disclosing my personal details and information relating to my contact information, training habits, race preparation, race experience, and ocean knowledge
- Be observed during the race on Llandudno beach to check whether I opt for the sin-bin or not
- My questionnaire results, entry data, and race results being used for this study provided that said information is kept secure, confidential and depersonalized should data be presented or published

I have been informed about the risks that are associated with participating in this study. Furthermore, I understand that during the course of this study my data will be treated with confidentiality and will only be used for scientific research.

I understand that I am free to withdraw from this study at any time without needing to provide reasoning. At the same time, I understand that the researcher may withdraw me from this study as well at any time. I have been informed that I may ask any questions related to this study.

I agree to participate in this study.

Participant

_________________________ ☑ _________________

Full name Consent Date

Investigator

____________________ ____________________ _________________

Full name Signature Date

Appendix 4: Total SwimRun Questionnaire

Dear Sir/Madam,

Thank you for participating in this study!

You are about to complete a questionnaire asking questions regarding the following: training habits, SwimRun race preparation, SwimRun race experience, and ocean knowledge.

This questionnaire should take you about 15-20 minutes to complete. Please read the questions carefully throughout the questionnaire. Once you are finished, please click "submit". You will be able to go back to previous questions to check your answers again.

If any of the questions are unclear, feel free to contact the student investigator:

Christina Geromont

Grmchr005@myuct.ac.za

073 922 0040

Section A – Contact Details

Full Name:

Email:

Cellphone/telephone:

Section B – General

Age (on 17 November 2019):

Current weight (kg):

Height:

Sex: M/F

Category entered: Male team/ Mixed team/ Female team

Section C – Training Habits

1. Please select the sports that you have performed regularly (i.e. done every week) in the last three (3) months

Swimming (pool)
Swimming (open water)
Running (road)
Running (trail)
Cycling (road)
Cycling (mtb)
Gymming (cardio)
Gymming (weights/resistance)
Canoeing/Surf Ski
Surfing
Prone/Malibu board

2. Please select what type of athlete you classify yourself as. You may choose two (2) options.

Option 1: Lifesaver
Triathlete
Biathlete
Paddler
Cyclist
Runner
Swimmer
Surfer

Option 2: Lifesaver
Triathlete
Biathlete

Paddler

Cyclist

Runner

Swimmer

Surfer

N/A

3. Select the number of sessions per week that you perform for each sport and the total number of hours of training per week that you participate in. For example, if you cycle on average three (3) times per week for six (6) hours (=360 minutes), select "Cycling" in the left column, and type "3" in the middle column and "360" in the right column. Do this for all sports that you perform.

Swimming (pool)	Number/week	min/week
Swimming (open water)		
Running (road)		
Running (trail)		
Cycling (road)		
Cycling (mtb)		
Gymming (cardio)		
Gymming (weights/resistance)		
Canoeing/Surf Ski		
Surfing		
Prone/Malibu board		

4. Please list your CURRENT five (5) kilometer road running time. For example, if you run it in thirty (30) minutes and six (6) seconds, type "30" in the left column (m) and "6" in the right column (s).

m s

5. Please list your CURRENT one (1) kilometer pool swimming time. For example, if you swim it in twenty (20) minutes and six (6) seconds, type “20” in the left column (m) and “6” in the right column (s).

m s

Section D – Race preparation

6. Please list your expected finishing time for the Torpedo SwimRun Cape 2019 race. Note that the race consists of six (6) swims totaling four (4) kilometers, and six (6) runs totaling twelve (12) kilometers. The race is, therefore, sixteen (16) kilometers in total. For example, if you believe that you will finish in three (3) hours and six (6) minutes, please type "3" in the left column (h) and "6" in the right column (m)

h m

7. Torpedo SwimRun requires mandatory equipment to be used, including wetsuit, swim cap, yellow vest, a whistle, and footwear. Optional gear includes goggles, hand paddles and pool buoy. Please select the following equipment that you will be using.

Wetsuit type:	Swimming suit (smooth rubber outside)
	Surfing suit (neoprene outside)
Wetsuit length:	Full sleeve
	Sleeveless
	Short-sleeve
Wetsuit thickness:	3.2mm
	4.3mm
	5.2mm
Shoe type:	Road running shoe

Trail running shoe

Minimalist running shoe

Slip slops

Surfing booties

Hand paddle use: Yes

No

Pool buoy use:Yes

No

Section E – Race Experience

8. What makes Torpedo SwimRun unique is that it takes competitors through the Atlantic coastline in Cape Town. This adds an additional edge to the race, where competitors are required to navigate themselves through waves, currents and be able to enter and exit swims on rocks as well. Please read the following statements:

a) "I am entirely comfortable swimming through all types of waves and currents."

On the following scale, please select which option you find describes your level of agreement best. Note that your answer will NOT exclude you from this race.

1 – Strongly disagree

2 – Disagree

3 – Neutral

4 – Agree

5 – Strongly agree

b) "I am entirely comfortable swimming in cold (sub 13-degree Celcius) ocean water."

On the following scale, please select which option you find describes your level of agreement best. Note that your answer will NOT exclude you from this race.

1 – Strongly disagree

2 – Disagree

3 – Neutral

4 – Agree

5 – Strongly agree

c) “I am knowledgeable in recognizing ocean currents.”

On the following scale, please select which option you find describes your level of agreement best. Note that your answer will NOT exclude you from this race.

1 – Strongly disagree

2 – Disagree

3 – Neutral

4 – Agree

5 – Strongly agree

d) “I am knowledgeable in entering and exiting all swims, which include sand, rock and seaweed terrain.”

On the following scale, please select which option you find describes your level of agreement best. Note that your answer will NOT exclude you from this race.

1 – Strongly disagree

2 – Disagree

3 – Neutral

4 – Agree

5 – Strongly agree

9. Have you completed any previous Torpedo SwimRuns before? Please select which race and number of times you have completed it. If you have participated in any Torpedo SwimRun organized reconnaissance, include that in the total number. For example, if you have done two (2) Cape Route races and one (1) reconnaissance, type in three (3).

None	0
Cape	Number
Wilderness	Number
Val de Vie	Number
Other SwimRuns	Number

10. In your previous Torpedo SwimRun races, did you experience cramping during the race?

Yes

No

Section F – Ocean Knowledge

Please answer the following questions to the best of your own knowledge, without the advice of anyone else or the use of other sources. This consists of ten (10) multiple choice questions. If you are unsure of the answer and feel that you would be guessing, please select the option "unsure". This questionnaire should take you about seven minutes to complete, with a time limit of ten minutes

1. Rip currents do not pull people under water – they pull people away from shore (True) (1)

True/False/Unsure

2. Undertows and riptides are the same as rip currents (False) (1)

True/False/Unsure

3. Rip currents only occur in the ocean (False) (1)

True/False/Unsure

4. Rip currents can be very narrow or more than 45m wide (True) (1)

True/False/Unsure

5. Rip currents do not affect strong swimmers (False) (1)

True/False/Unsure

6. A break in an incoming wave pattern could mean a rip current is present (True) (1)

True/False/Unsure

7. If you are caught in a rip current, it is important to fight the current (False) (1)

True/False/Unsure

8. Escape the rip current by swimming in a direction parallel to the shoreline (True) (1)

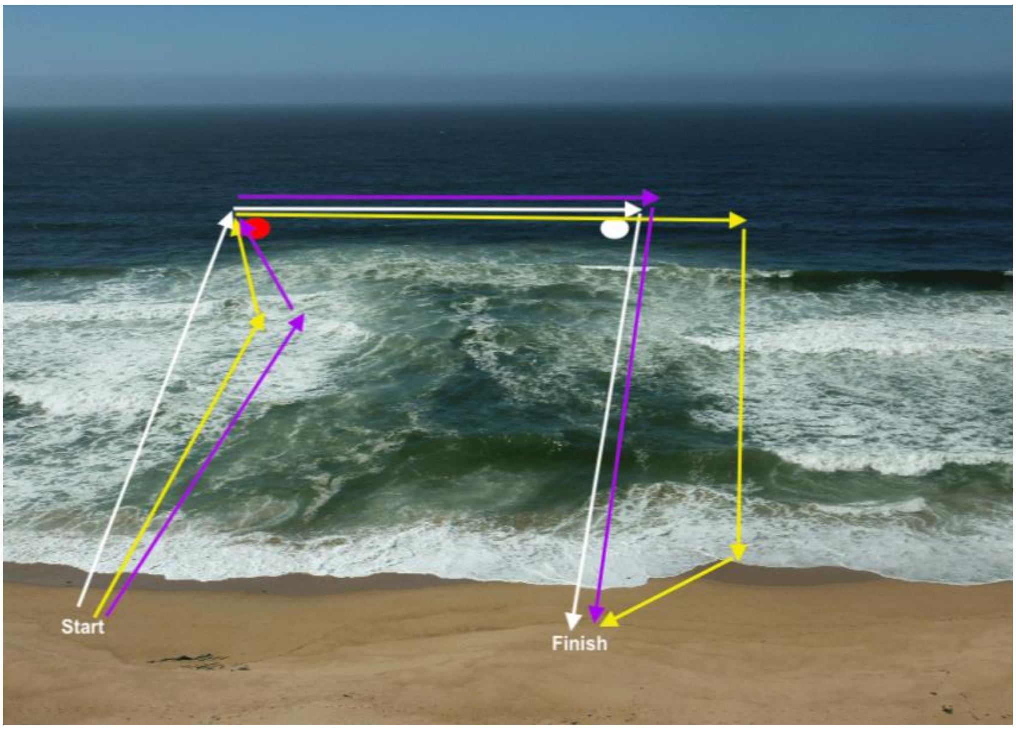
True/False/Unsure

9. When free of the current, swim at an angle toward the current (False) (1)

True/False/Unsure

10. Which route would you choose to go from the start, around the red dot, around the white dot and then to the finish the fastest and most efficiently? (Yellow) (3)

White/Yellow/Purple/Unsure



Appendix 5: Ocean Knowledge Questionnaire

Questions are adapted from a questionnaire that was developed by the United States Lifesaving Association (United States Lifesaving Association, 2019). Image sourced from Mackeller, Brander and Shaw, 2015.

Dear Sir/Madam,

Thank you for participating in this questionnaire study on ocean knowledge!

This questionnaire should take you about seven minutes to complete, with a time limit of ten minutes. Please read the questions carefully and answer based on your knowledge, without checking outside sources. You will be able to go back to previous questions to check your answers again.

Once you are finished, please click "submit".

If any of the questions are unclear, feel free to contact the investigator:

Christina Geromont

Grmchr005@myuct.ac.za

073 922 0040

Section A – Personal information

Full name:

Email:

Cellphone/telephone:

Category: Lifeguard/ Beach-goer (familiar with beaches and the ocean)/ Non beach-goer

How many hours per month, on average, do you spend in the ocean?: ___ hrs

Date of Birth:

Section B – Ocean Knowledge

Please answer the following questions to the best of your own knowledge, without the advice of anyone else or the use of other sources. This consists of ten (10) multiple choice questions. If you are unsure of the answer and feel that you would be guessing, please select the option “unsure”.

1. Rip currents do not pull people under water – they pull people away from shore (True) (1)

True/False/Unsure

2. Undertows and riptides are the same as rip currents (False) (1)

True/False/Unsure

3. Rip currents only occur in the ocean (False) (1)

True/False/Unsure

4. Rip currents can be very narrow or more than 45m wide (True) (1)

True/False/Unsure

5. Rip currents do not affect strong swimmers (False) (1)

True/False/Unsure

6. A break in an incoming wave pattern could mean a rip current is present (True) (1)

True/False/Unsure

7. If you are caught in a rip current, it is important to fight the current (False) (1)

True/False/Unsure

8. Escape the rip current by swimming in a direction parallel to the shoreline (True) (1)

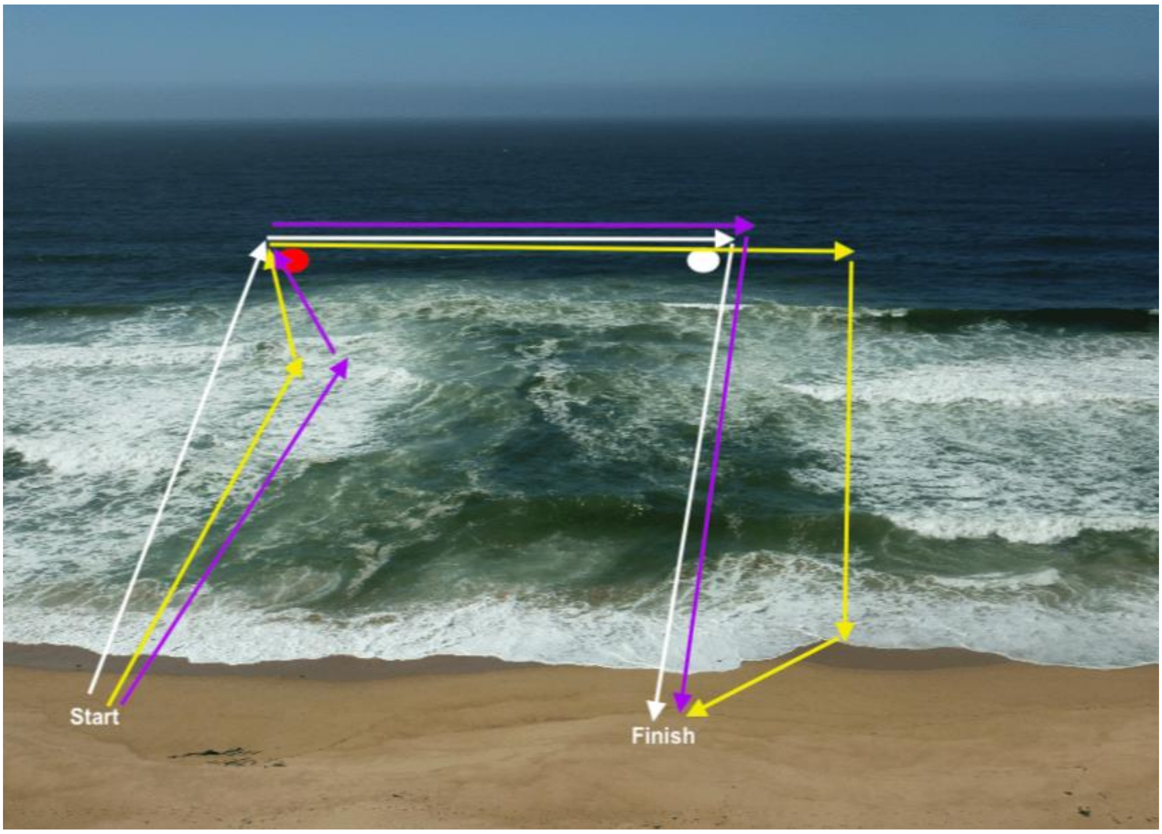
True/False/Unsure

9. When free of the current, swim at an angle toward the current (False) (1)

True/False/Unsure

10. Which route would you choose to go from the start, around the red dot, around the white dot and then to the finish the fastest and most efficiently? (Yellow) (3)

White/Yellow/Purple/Unsure



Appendix 6: Informed consent for only Ocean Knowledge Questionnaire Validation

Dear Sir or Madam,

Thank you for considering participating in this study, which is being conducted by a research team from the Division of Exercise Science and Sports Medicine (Department of Human Biology, University of Cape Town). This following section describes why this study is being conducted, what it involves for a participant, the risks of participation, ethical considerations, the contact information of the researchers and the details around providing consent to participate.

Scope and purpose of the research

SwimRun is a relatively new sport, which was founded in Sweden about 15 years ago. The sport has spread throughout the world, including South Africa.

Despite the growth of this sport, no research has been conducted on this field. As part of a bigger research question, we are interested in determining the effect of one's ocean knowledge on race performance. However, a questionnaire to assess a person's ocean knowledge has not been validated. In order to validate such a questionnaire, participants of different levels of ocean experience are required to complete this questionnaire.

What are the aims of this sub-study?

The aim of this study is to validate the usefulness of an ocean knowledge questionnaire that this research group constructed. The objective is to analyze scores of three different pre-selected ocean knowledge groups (lifeguards, beachgoers and non-beachgoers) and to see if there are significant score differences between the three groups.

Who is eligible to participate?

Anyone that is over the age of 18, and is either a lifeguard, a beachgoer, or a non-beachgoer (rarely goes to the beach or has little interest in it).

What will the sub-study involve?

If you agree to participate, an informed consent form will be provided to you to sign. At any point will you be able to ask any of the researchers questions that are related to this study.

After signing consent, you will be provided with one ocean knowledge questionnaire. This questionnaire consists of ten (10) questions relating to your ocean and beach knowledge. You will also be asked to fill in your contact information, date of birth and the category that you classify yourself into.

Thereafter, your score will be recorded and analyzed.

Are there any risks in participating in this study?

There are no risks associated with completing the questionnaire. All data will be kept confidentially on secure computers and will not be shared with any party outside of the research team without the consent of the participant. Prior to presenting data and results, all information will be depersonalized in such a way that no information can be linked to you.

Are there any benefits in participating in this study?

There is no direct personal benefit in taking part in this study. You will however receive feedback, which you may find useful, after completing the questionnaire.

Ethical considerations

This study has been approved by the University of Cape Town Human Research Committee. This means, that this study will be conducted according to the principles of the Declaration of Helsinki (2013, Fortaleza, Brazil) and the laws of South Africa. Participants will only be able to participate in this study once they have signed a consent form and are aware of their voluntary participation. Participants may withdraw from this study at any stage without having to provide a reason. The investigator will also be able to withdraw a participant from the study at any time. It will be the investigator's responsibility to keep all information confidential. This will be done by keeping all data on encrypted computers on a secure facility. Only the research team of this study will have access to (unless the participant provides consent to sharing information). Should the data be published or presented, all information will be depersonalized.

What if something goes wrong?

The University of Cape Town will not be responsible for any injury, loss and/or harm that may be sustained where the loss is caused by:

- Not following protocol instructions that are provided by the investigator
- Injury, harm and/or loss that is caused by lack or insufficient action to deal adequately with a side effect
- Negligence on your part

If I have any questions or concerns, who can I speak to?

If you have any ethical concerns or queries, please contact the Human Research Ethics Committee.

University of Cape Town Research Ethics Committee
Room E24-25, Faculty of Health Sciences, Old Main Building of Groote Schuur Hospital
Anzio Road, Observatory
7925
Email: marc.blockman@uct.ac.za

Any queries related to the study itself, please contact any of the investigators.

Christina Geromont

Sports Science Institute of South Africa

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Boundary Road, Newlands

7725

Telephone: 021 6504558

Email: mike.lambert@uct.ac.za

CONSENT

I, the undersigned, have been informed about the University of Cape Town's study, "TORPEDO SWIMRUN CAPE TOWN: UNDERSTANDING ATHLETES, EVALUATION OF RACE RULES AND ASSESSING PREDICTORS OF PERFORMANCE OF A NOVEL SPORT", which is to be conducted by the Division of Exercise Science and Sports Medicine within the Department of Human Biology, Faculty of Health Sciences.

I agree to:

- Complete a questionnaire disclosing my personal details and information relating to my contact information and ocean knowledge
- My questionnaire results being used for this study provided that said information is kept secure, confidential and depersonalized should data be presented or published

I have been informed about the risks that are associated with participating in this study. Furthermore, I understand that during the course of this study my data will be treated with confidentiality and will only be used for scientific research.

I understand that I am free to withdraw from this study at any time without needing to provide reasoning. At the same time, I understand that the researcher may withdraw me from this study as well at any time. I have been informed that I may ask any questions related to this study.

I agree to participate in this study.

Participant

____________________	____________________	__________________
Full name	Signature	Date

Investigator

____________________	____________________	__________________
Full name	Signature	Date

Appendix 7: Training variables of SwimRun athletes

Table 5: Training variables of SwimRun athletes. Only median and interquartile ranges are shown due to all variables being non-parametrically distributed. IQR (interquartile range), S-W (Shapiro-Wilk test). *significance.

	Variable	Median	IQR	S-W *p* value
Sessions (number/week)	Pool swimming	2	2	0.001*
	Open-water swimming	0	1	0.001*
	Road running	2	3	0.001*
	Trail running	0	1	0.001*
	Road cycling	0	1	0.001*
	Mountain bike	0	1	0.001*
	Gymming (cardio)	0	2	0.001*
	Gymming (resistance)	0	2	0.001*
	Paddling	0	0	0.001*
	Surfing	0	1	0.001*
	Prone board	0	0	0.001*
	Other	0	0	0.001*
Duration (min/week)	Pool swimming	60	60	0.001*
	Open-water swimming	45	60	0.001*
	Road running	60	135	0.001*
	Trail running	0	105	0.001*
	Road cycling	0	90	0.001*
	Mountain bike	0	0	0.001*
	Gymming (cardio)	0	60	0.001*
	Gymming (resistance)	0	60	0.001*
	Paddling	0	0	0.001*
	Surfing	0	60	0.001*
	Prone board	0	0	0.001*
	Other	0	0	0.001*

Appendix 8: Personal race confidence of SwimRun athletes

Table 6: Personal race confidence of SwimRun athletes. Only median and interquartile ranges are shown due to all variables being non-parametrically distributed. IQR (interquartile range), S-W (Shapiro-Wilk test). *significance. Participants were asked to indicate their answers on a Likert scale (1: least confident; 5: most confident).

Variable	Median	IQR	S-W *p* value
Comfort in waves and currents	4	2	0.001*
Comfort in cold water	3	2	0.001*
Knowledge of ocean currents	4	2	0.001*
Confidence entering and exiting swims	4	2	0.001*

Appendix 9: Ocean Knowledge Validation

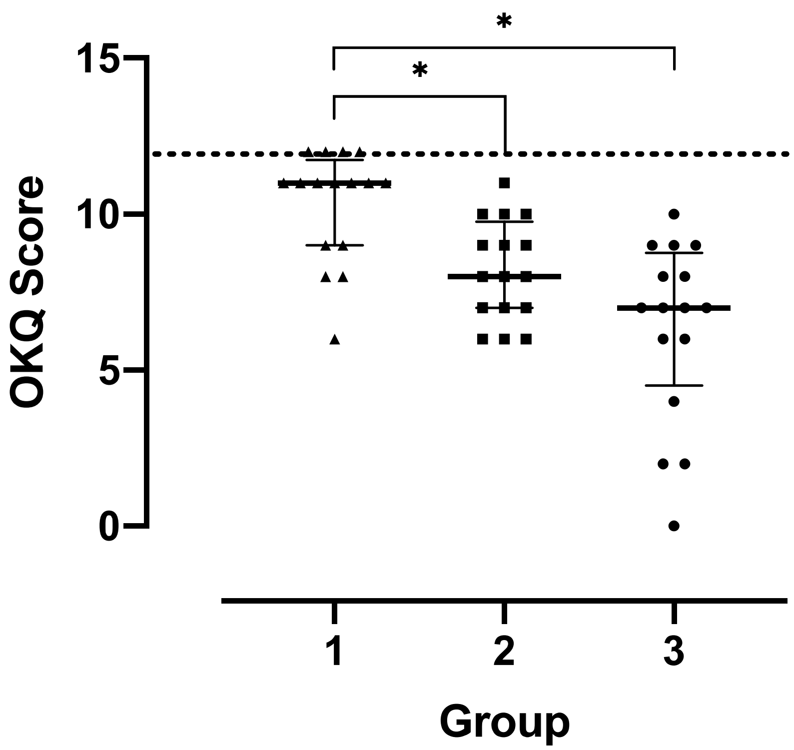

Figure 5: Ocean Knowledge Questionnaire validation. Group 1: lifeguards. Group 2: beach-goers. Group 3: non beach-goers. Each column shows all individuals' scores, the group median and the group interquartile range. The dotted line represents the maximum score possible, which is 12. A Kruskal-Wallis test was used to compare the three groups. *significance.